CLAIMS

1. An accelerometer, comprising:

a monocrystalline silicon wafer etched to form a fixed portion, a movable portion, and a resilient coupling between, the fixed and movable portions generally arranged in the plane of the wafer, the mass of the movable portion being concentrated on one side of the resilient coupling;

one of the fixed and moveable portions of the silicon structure including a first electrode oriented parallel to an axis of acceleration, the other of the fixed and moveable portions including a second electrode oriented parallel to the axis of acceleration, the other of the fixed and moveable portions bearing a metal layer mechanically coupled with the second electrode and electrically connected as a third electrode coplanar with the second electrode, the second and third electrodes being stacked in a direction parallel to the axis of acceleration and arranged in capacitive opposition to the first electrode;

a resilient coupling designed to retain the first and third electrodes in capacitive opposition to each other across a capacitance gap while allowing motion of the first electrode relative to the second and third electrodes in response to acceleration along an axis of acceleration perpendicular to the plane of the wafer, and to resiliently restore the first electrode to an equilibrium position relative to the second and third electrodes when the acceleration ceases, the second electrode being in opposition to a majority of the surface area of the first electrode when the electrodes are in the equilibrium position, the capacitance gap being oriented parallel to the axis of acceleration, the capacitance between the first electrode and third electrode increasing as the movable portion moves away from the equilibrium position in a direction along the axis of acceleration and decreasing as the movable portion moves in an opposite direction away from the equilibrium position; and

electronics and/or software designed to translate a measurement of capacitance between the first and third electrodes into a measurement of acceleration along the axis.

2. An accelerometer, comprising:

a fixed structure and a movable structure, the fixed and movable structures generally arranged in a plane, the fixed structure bearing a fixed electrode, the movable structure bearing a movable electrode;

a resilient coupling designed to retain the fixed and movable structures in capacitive opposition to each other across a capacitance gap while allowing motion of the movable electrode relative to the fixed electrode in response to acceleration along an axis of acceleration perpendicular to the plane, and to resiliently restore the two electrodes to an equilibrium position when the acceleration ceases; and

electronics and/or software designed to translate a measurement of capacitance between the fixed and movable electrodes into a measurement of the acceleration along the axis.

3. The accelerometer of claim 2, wherein the fixed structure, movable structure and resilient coupling are formed primarily of silicon.

4. The accelerometer of claim 3, wherein the fixed structure and movable structure are formed at least primarily of high aspect ratio beams.

5. The accelerometer of claim 3, wherein one of the fixed and movable electrodes is formed of silicon, being a first electrode, and the other electrode is formed as an electrically-conductive layer on a silicon structural member, being a second electrode.

6. The accelerometer of claim 5, wherein:

the silicon structural member is electrically connected as a third electrode coplanar with the second electrode, the second and third electrodes being arranged in capacitive opposition to the first electrode.

7. The accelerometer of claim 6, wherein the third electrode is connected to a ground potential.

8. The accelerometer of claim 5, wherein the first electrode is formed as a high-aspect-ratio beam with a larger cross-sectional dimension of the beam oriented parallel to the axis of acceleration.

9. The accelerometer of claim 3, wherein:

a silicon wafer is etched to form the fixed structure and the movable structure.

10. The accelerometer of claim 9, wherein:

various structures of the movable and fixed structures are electrically isolated from each other by isolation joints formed within the silicon wafer.

11. The accelerometer of claim 9, wherein:

various structures etched from the wafer are released from an underlying substrate of the silicon wafer.

12. The accelerometer of claim 2, wherein:

the electronics and/or software measure differential capacitance between at least two pairs of electrodes, and translate the measured differential capacitance into an expression of acceleration.

13. The accelerometer of claim 2, wherein:

a capacitance between the fixed and movable electrode is at a maximum when the movable structure is displaced from the equilibrium position.

14. The accelerometer of claim 2, wherein:

the resilient coupling is a torsional flexure.

15. The accelerometer of claim 14, wherein:

the resilient coupling is integrally etched from the silicon wafer with the fixed and movable structures.

16. The accelerometer of claim 2, further comprising:

fixed and movable electrodes arranged in first and second regions, such that

motion in a direction of the movable structure results in increased capacitance between electrodes in the first region and decreased capacitance in the second region; and

motion in an opposite direction of the movable structure results in decreased capacitance between electrodes in the first region and increased capacitance in the second region.

17. The accelerometer of claim 2, wherein the mass of the movable structure is concentrated on one side of the resilient coupling.

18. A method, comprising the steps of:

applying an acceleration to a fixed structure and a movable structure, the fixed and movable structures generally arranged in a plane perpendicular to an axis of the acceleration, the fixed structure bearing a fixed electrode, the movable structure bearing a movable electrode;

in response to the acceleration, allowing motion of the movable electrode relative to the fixed electrode, a resilient coupling retaining the fixed and movable structures in capacitive opposition to each other across a capacitance gap;

and movable

resiliently restoring the two electrodes to an equilibrium position when the acceleration ceases; and

measuring capacitance between the movable and fixed electrodes, and translating the measured capacitance into an expression of the acceleration.

19. The method of claim 18, wherein:

one of the fixed and moveable electrodes is formed of silicon, and the other of the fixed and moveable electrodes is formed as an electrically-conductive layer deposited on a silicon structure.

20. The method of claim 18, wherein:

electrodes of movable and fixed portions of the accelerometer are arranged in first and second regions, such that

motion in a direction of the movable portion results in increased capacitance between electrodes in the first region and decreased capacitance in the second region; and

motion in an opposite direction of the movable portion results in decreased capacitance between electrodes in the first region and increased capacitance in the second region.

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21. The method of claim 18, wherein:

the resilient coupling is a torsional flexure.

22. An accelerometer, comprising:

a fixed portion and a movable portion, the fixed and movable portions generally arranged in a plane;

a resilient coupling designed to allow motion of the movable portion relative to the fixed portion in response to acceleration along an axis of acceleration perpendicular to the plane and to resiliently restore the two portions to an equilibrium position when the acceleration ceases;

fixed/movable [uncertain reading]

one of the fixed and moveable portions being electrically connected as a first electrode, the other of the fixed and moveable portions bearing an electrically-conductive layer electrically connected as a second electrode, the first and second electrodes being arranged in capacitive opposition to each other;

electronics and/or software designed to translate a measurement of capacitance between the first and second electrodes into a measurement of acceleration along the axis.

23. The accelerometer of claim 22:

wherein a silicon wafer is etched to form the fixed portion and the movable portion.

24. The accelerometer of claim 23, wherein:

the mass of the movable portion is concentrated on one side of the resilient coupling.

25. The accelerometer of claim 23, wherein:

the resilient coupling is integrally etched from the silicon wafer with the fixed and movable portions.

26. The accelerometer of claim 23, wherein:

a substantial portion of the movable portion is manufactured by a process including a step of releasing the movable portion from an underlying substrate of the wafer.

27. The accelerometer of claim 23, wherein:

various portions of the movable and fixed portions are electrically isolated from each other by isolation joints formed within the silicon wafer.

28. The accelerometer of claim 23, wherein:

wherein the second electrode is formed as a layer mechanically coupled with and electrically isolated from the silicon of the movable portion.

29. The accelerometer of claim 22, wherein:

the resilient coupling is formed from a solid of high modulus of elasticity.

30. The accelerometer of claim 22, wherein:

the resilient coupling is a torsional flexure.

31. The accelerometer of claim 22, wherein:

the movable portion includes a stop designed to engage a floor of the fixed portion to limit excess motion.

32. The accelerometer of claim 22, wherein:

electrodes of the movable and fixed portions are arranged in first and second regions, such that:

motion in a direction of the movable portion results in increased capacitance between electrodes in the first region and decreased capacitance in the second region; and

motion in an opposite direction of the movable portion results in decreased capacitance between electrodes in the first region and increased capacitance in the second region.

33. The accelerometer of claim 22, wherein:

the capacitance between the first electrode and second electrode increasing as the movable portion moves away from the equilibrium position in a direction along the axis of acceleration and decreasing as the movable portion moves in an opposite direction.

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34. A method, comprising the steps of:

establishing an electric field between a movable electrode and a fixed electrode of an accelerometer, the movable and fixed electrodes being arranged in capacitive opposition to each other, one of the fixed and moveable electrodes being formed of silicon, the other of the fixed and moveable electrodes being formed as an electrically-conductive layer mechanically coupled with and electrically isolated from a silicon structure and stacked with the silicon structure in a direction of an axis of acceleration, the silicon structure being generally coplanar with the electrode formed of silicon;

allowing motion of movable electrode relative to the fixed electrode in response to an acceleration along the axis of acceleration, and allowing a resilient coupling to restore the two electrodes to an equilibrium position when the acceleration ceases;

measuring capacitance between the movable and fixed electrodes, and translating the measured capacitance into an expression of the acceleration.

35. The method of claim 34, wherein:

the electrode formed of silicon is a first silicon electrode; and

the silicon structure on which the conductive-layer electrode is formed is electrically connected as a second silicon electrode, the conductive-layer electrode and second silicon electrode being arranged in capacitive opposition to the first silicon electrode, the second silicon electrode being in opposition to a majority of the surface area of the first silicon electrode when the electrodes are in the equilibrium position.

36. The method of claim 34, wherein:

the predominant structural members of the accelerometer are formed by etching a silicon wafer.

37. The method of claim 36, wherein:

the resilient coupling is integrally etched from the silicon wafer.

38. An accelerometer, comprising:

a silicon wafer etched to form a fixed portion, a movable portion, and a resilient coupling between, the fixed and movable portions generally arranged in a plane, the resilient coupling designed to allow motion of movable portion relative to the fixed portion perpendicular to the wafer in response to acceleration perpendicular to the wafer and to resiliently restore the two portions to an equilibrium position when the acceleration ceases, the mass of the movable portion being concentrated on one side of the resilient coupling;

the fixed and moveable portions each bearing an electrode, the electrodes being arranged in capacitive opposition; and

electronics and/or software designed to translate a measurement of capacitance between the first and second electrodes into a measurement of acceleration perpendicular to the wafer.

39. The accelerometer of claim 38, further comprising:

a third electrode coplanar with and mechanically coupled to the movable electrode, the movable and third electrodes being arranged in capacitive opposition to the fixed electrode, the third electrode being in opposition to a majority of the surface area of the fixed electrode when the electrodes are in the equilibrium position.

40. The accelerometer of claim 38, further comprising:

one of the fixed and moveable portions of the silicon structure being electrically connected as a first electrode, the other of the fixed and moveable portions bearing an electrically-conductive layer electrically connected as a second electrode, the first and second electrodes being arranged in capacitive opposition to each other.

41. The accelerometer of claim 38, wherein:

a silicon wafer is etched by a dry-etch process to form the fixed portion and the movable portion.

42. The accelerometer of claim 38, wherein:

electrodes of the movable and fixed portions are arranged in first and second regions, such that:

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motion in a direction of the movable portion results in increased capacitance between electrodes in the first region and decreased capacitance in the second region; and

motion in an opposite direction of the movable portion results in decreased capacitance between electrodes in the first region and increased capacitance in the second region.

43. The accelerometer of claim 38, wherein:

the resilient coupling is integrally etched from the silicon wafer with the fixed and movable portions.

44. The accelerometer of claim 38, wherein:

the resilient coupling is formed from a solid of high modulus of elasticity.

45. The accelerometer of claim 38, wherein:

the resilient coupling is a torsional flexure.

46. The accelerometer of claim 38, wherein:

the movable portion includes a stop designed to engage a floor of the fixed portion to limit excess motion.

47. The accelerometer of claim 38, wherein:

a substantial portion of the movable portion is manufactured by a process including a step of releasing the movable portion from an underlying substrate of the wafer.

48. A method of detecting acceleration along an axis of acceleration, comprising the steps of:

establishing an electric field between a movable electrode and a fixed electrode of an accelerometer, the movable and fixed electrodes being arranged in capacitive opposition to each other and being mechanically borne on movable and fixed portions, respectively, of a structure etched from a silicon wafer, the fixed and movable portions generally arranged in a plane,

allowing motion perpendicular to the wafer of the movable electrode relative to the fixed electrode in response to an acceleration perpendicular to the wafer, and allowing a resilient

coupling to restore the two electrodes to an equilibrium position when the acceleration ceases, the mass of the movable portion being concentrated on one side of the resilient coupling; and

measuring capacitance between the movable and fixed electrodes, and translating the measured capacitance into an expression of the acceleration.

49. The accelerometer of claim 48, wherein:

limiting excess motion of the movable portion by urging a stop against a floor of the fixed portion, the stop being cantilevered from the movable portion in a direction generally opposite the direction of the concentrated mass.

50. The accelerometer of claim 48, wherein:

the capacitance between the first electrode and second electrode increases as the movable portion moves away from the equilibrium position in a direction along the axis of acceleration and decreases as the movable portion moves in an opposite direction.

51. The accelerometer of claim 50, wherein:

the capacitance between the first electrode and the second electrode reaches a maximum when the movable portion has moved from the equilibrium position by a distance of about half the depth of the fixed portion.

52. An accelerometer, comprising:

first, second and third electrodes, the second electrode being coplanar with the third electrode, the second and third electrodes being arranged in capacitive opposition to the first electrode across a capacitance gap;

a resilient coupling designed to allow motion of the first electrode relative to the second and third electrodes along the axis of acceleration in response to acceleration and to resiliently restore the first electrode to an equilibrium position when the acceleration ceases, the second electrode being in opposition to a majority of the surface area of the first electrode when the electrodes are in the equilibrium position; and

electronics and/or software designed to translate a measurement of capacitance between the first and third electrodes into a measurement of acceleration along the axis.

53. The accelerometer of claim 52:

wherein a silicon wafer is etched to form the first and second electrodes; and

the axis of acceleration is perpendicular to the wafer.

54. The accelerometer of claim 53, wherein the third electrode is formed as an electrically-conductive layer mechanically coupled to the silicon of the second electrode.

55. The accelerometer of claim 53, wherein:

the capacitance between the first electrode and third electrode increases as the movable portion moves away from the equilibrium position in a direction along the axis of acceleration and decreases as the movable portion moves in an opposite direction.

56. The accelerometer of claim 53, wherein:

the third electrode is formed as a layer of electrically-conductive material that is mechanically coupled with and electrically isolated from the silicon of the movable portion.

57. The accelerometer of claim 53, wherein:

various structures etched from the wafer are electrically isolated from each other by isolation joints formed within the silicon wafer.

58. The accelerometer of claim 53, wherein:

various structures etched from the wafer are released from an underlying substrate of the silicon wafer.

59. The accelerometer of claim 52, wherein:

the second electrode is electrically connected to consume field lines from the capacitance gap.

1 60. A method, comprising the steps of:

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establishing an electric field between first, second and third electrodes of an accelerometer, the second and third electrodes being arranged in capacitive opposition to the first electrode, the first, second and third electrodes being mechanically borne on movable and fixed portions of an accelerometer, the second and third electrodes being mechanically coupled and generally coplanar with each other;

allowing motion, perpendicular to the plane generally containing the second and third electrodes, of the movable portion relative to the fixed portion in response to an acceleration, and allowing a resilient coupling to restore the electrodes to an equilibrium position when the acceleration ceases, the second electrode being in opposition to a majority of the surface area of the first electrode when the electrodes are in the equilibrium position; and

measuring capacitance between the first and third electrodes, and translating the measured capacitance into an expression of the acceleration.

61. The method of claim 60, wherein:

the fixed portion and the movable portion are etched from a silicon wafer.

62. The method of claim 61, wherein:

the first and second electrodes are etched out of silicon.

63. The method of claim 61, wherein:

the third electrode is formed as a layer of electrically-conductive material that is mechanically coupled with and electrically isolated from the silicon of the movable portion.

64. The method of claim 63, wherein:

the first and third electrodes are arranged relative to each other so that motion of the movable portion away from the equilibrium position in one direction increases capacitance between the first and third electrodes, and motion in an opposite direction from the equilibrium position decreases capacitance between the first and third electrodes.

65. The method of claim 60, further comprising the steps of:

measuring differential capacitance between at least two pairs of electrodes; and

translating the measured differential capacitance into an expression of acceleration.

66. The method of claim 60, wherein:
the mass of the movable portion is concentrated on one side of the resilient coupling.